ELECTRIC MOBILITY IN THE BALTICS

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Abstract: *The Baltic States have no fuel resources needed for internal combustion engines. Oil products are imported. Internal combustion automobiles make a negative effect on the surrounding environment, as they produce toxic emissions and noises. One of the ways how to use electric energy – a resource produced in the Baltic States – is the exploitation of electric vehicles. The use of electric vehicles in the Baltic States began in 2010. Since this year, the best infrastructures for electric vehicles and their charging have been created in Estonia. The paper analyses the quantitative and qualitative specifics of electric vehicles and their infrastructures in the Baltic States as well as reviews the development prospects.*

Keywords: ELECTRIC VEHICLES, CHARGING POINTS, ALGORITHM OF CALCULATION, NUMBER OF CHARGING STATIONS, NUMBER OF ELECTRIC VEHICLES

1. Introduction

At present, electric vehicles of several kinds are exploited in the Baltic States. Electric bicycles were among the first electric vehicles to appear in the market. Initially, electric bicycles used lead-gel batteries. Over the past three years, lithium-ion batteries were also used, yet, such a structure raises the cost of a bicycle by 30-35%. Compared with other electric vehicles, electric bicycles have significant advantages, for example, comparatively low prices and exploitation costs as well as a possibility to continue riding by pedalling if their batteries are discharged. Bicycles belong to the group of electric vehicles that can be relatively easily and cheaply converted into electric vehicles, using a standard electric bicycle conversion kit.

The firm Impresso which sells low-speed electric vehicles operates in Latvia since 2007 [1]. The speed of low-speed electric vehicles is within a range of 25-45 km/h, and a few modifications of them may participate in road traffic. Low-speed electric vehicles are used on golf courses and in other closed territories, for example, in sea ports and in the territory of Latvia's Children's Hospital. Such vehicles are mainly used for tourist tours in the towns of Sigulda and Jurmala.

The year 2010 may be regarded as the year when the use of electric vehicles was begun in the Baltic States; the exploitation of converted electric vehicles was started in Lithuania and Estonia. In 2011, two Fiat Fiorino electric vehicles were begun to be used in Latvia [2]. These vehicles were the first mass-production electric automobiles that were registered for road traffic in Latvia. In 2011, a charging infrastructure began developing in the Baltic States as well. Due to the fact that serious electric mobility involves the introduction of passenger electric vehicles, the paper will analyse in detail particularly this kind of electric mobility.

2. Aspects of electric mobility

In order to provide electric mobility, first of all, electric vehicles are necessary. Charging stations or other kinds of charging devices, sales of electric vehicles and their spare parts, technical support and repairs contribute to a wider use of electric vehicles. With electric vehicles developing, such vehicles are used for passenger transport, in agriculture and for water and air transport.

Electric vehicles may be charged from the regular 220 V alternating current mains as well as at fast- or medium fast-charging stations. At fast-charging stations, 80% of the full battery capacity can be recharged in 30 minutes. A classification of the most popular energy replenishment stations for electric vehicles developed according to their uses is presented in Figure 1.

Charging stations may be publicly available or located in closed territories where only the owners of a charging station may recharge their vehicles. If exploiting a small number of electric automobiles in a region, charging services at expensive charging stations are unprofitable for their owners, as their payback period is too long.

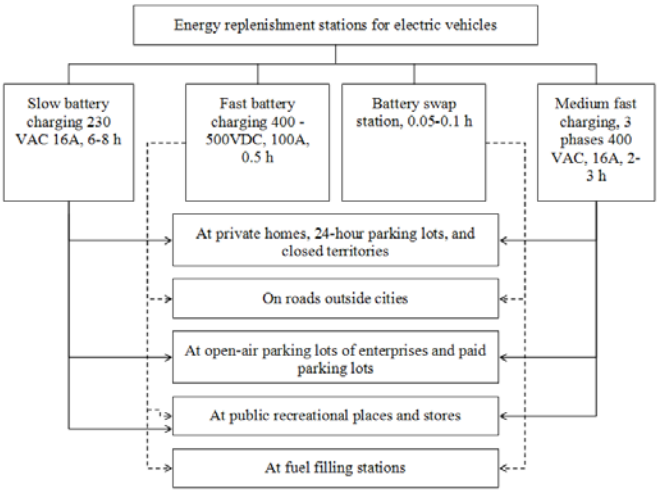

Fig.1. *Energy replenishment stations for electric vehicles*

Auto manufacturers usually set high standards for electric vehicle maintenance stations, for example, a charging station of certain design must be established in the territory of the maintenance station and specific tools must be purchased.

3. Electric automobiles in the Baltic States

In comparison with internal combustion engine automobiles, electric automobiles are expensive.

The opportunities for their use are limited as well. For this reason, a faster increase in the number of electric automobiles may be observed when government support is provided. Such a trend was observed both in Latvia in 2014 when 176 electric automobiles were purchased within a CCFI project and in Estonia in the period 2011-2014 within the Elmo project, purchasing 486 electric automobiles [3, 4, 5].

In Estonia the most popular electric automobile, purchased within the project, was Nissan Leaf (266 automobiles), while in Latvia 5 automobiles of this model were bought. In Latvia, the most popular electric automobile was Volkswagen e-Up (135 electric automobiles), while in Estonia 14 automobiles of this model were purchased. The distribution of other electric automobiles by model, purchased under the government support schemes in Latvia and Estonia, is shown in Figure 2.

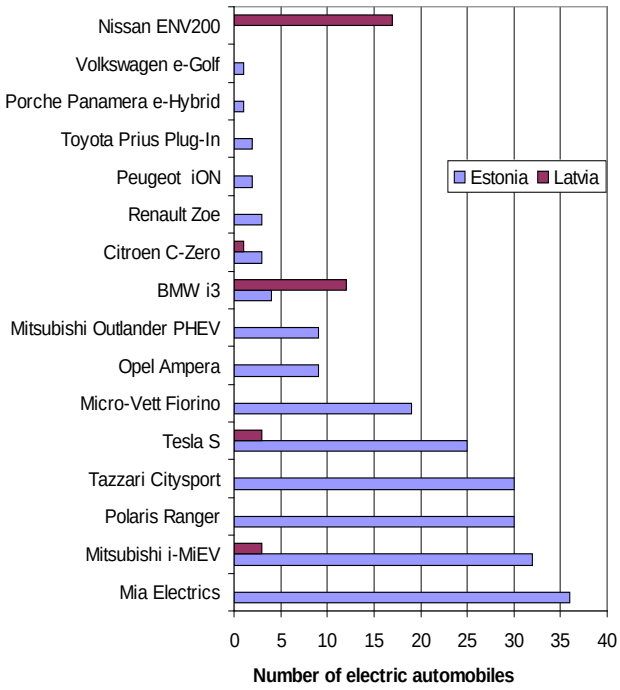

Fig. 2. *Distribution of electric automobiles, purchased under the government support schemes, by mode*

4. Algorithm for calculating the characteristics of electric mobility

An algorithm for calculating various comparable indicators has to be created to perform a comparative analysis of electric mobility in the Baltics. The number of charging stations in an analysed region may be calculated as follows:

$$N_S = \frac{S}{N_{CP}}, \quad (1)$$

where S – area of the analysed region, km^2;
N_{CP} – number of charging stations in the analysed region.

The number of charging stations on main roads may be calculated according to the formula:

$$N'_L = \frac{L_{mag}}{N_{CP}}, \quad (2)$$

where L_{mag} – length of the analysed main roads, km.

The smaller this indicator is, the better quality infrastructure is available outside cities and charging stations are available within shorter ranges.

The efficiency of introduction of electric vehicle charging stations is expressed by the number of the stations constructed per year:

$$N_{CP/Y} = \frac{n_{CP}}{T}, \quad (3)$$

where n_{CP} – number of electric vehicle charging stations constructed in the analysis period, units;
T – analysis period, usually measured in years.

The ratio of the number of charging stations to the number of electric automobiles or the number of electric automobiles per charging station:

$$I_{EV} = \frac{N_{EV}}{N_{CP}}, \quad (4)$$

where NEV – number of electric vehicles in the analysed region;
NCP – number of charging stations in the analysed region [6].

This indicator is important until the moment when a sufficient number of electric vehicle charging stations is available in the country.

An analysis of electric mobility may be performed employing indicators such as number of electric vehicles per charging station and per charging spot, population per charging station, availability ratio for charging stations and the average number of charging spots per station, but an analysis of such characteristics is available in another research study by the authors of the present research [6, 7].

5. Calculation results and analysis of the characteristics of electric mobility

The data used for the calculations are summarised in Table 1.

Table 1: *Characteristics used for the calculations.*

Indicator	Latvia	Lithuania	Estonia
Number of electric vehicles	194	69	1163
Number of charging stations	15	14	165
Area, km^2	64589	65303	45226
Main roads, km	1653	6667	3993
Distance to the nearest charging station, km	260	180	50
Average electric vehicle range, km	130		

The density of charging stations in the analysed region are presented in Figure 3.

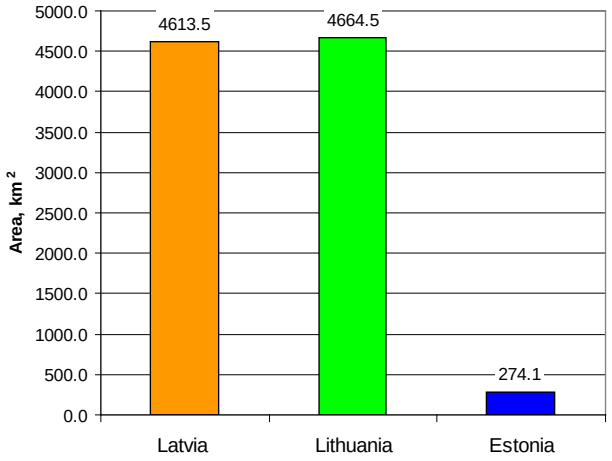

Fig. 3. *Density of charging stations*

An analysis of the number of charging stations per area shows that the situation in Lithuania and Latvia is similar – a charging station per 4.6 thousand square kilometers, – which is quite insufficient. In Estonia, its network of charging stations fully ensures travelling over the entire territory, with a charging station per 274 km^2.

The numbers of charging stations on main roads are presented in Figure 4.

An analysis of the locations of stations in relation to the main roads is not very objective, as the total length of motor roads in Latvia is the shortest, and only one charging station is available on motor roads outside cities. If calculated per total length of main motor roads, the best situation is in Estonia – one station per distance of 24 km.

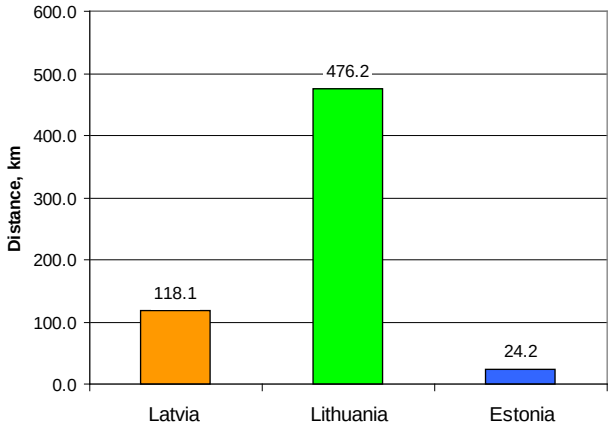

Fig. 4. *Density of charging stations on main roads*

The efficiencies of introduction of electric vehicle charging stations are expressed by the number of the stations constructed per year and are shown in Figure 5.

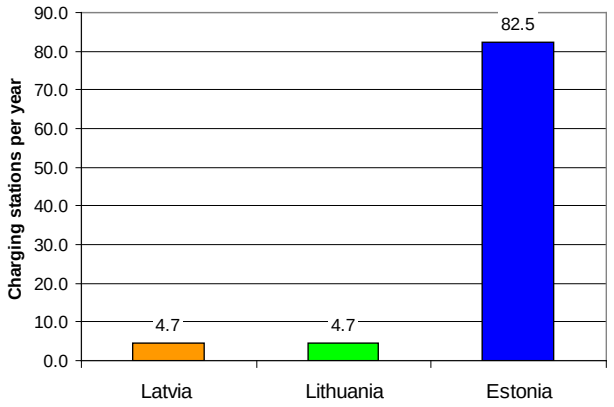

Fig. 5. *Introduction efficiency of charging stations*

The introduction rate of charging stations in Estonia is excellent, reaching 82 stations per year. In Latvia and Lithuania, this indicator is 16 times lower.

The ratio of the number of charging stations to the number of electric automobiles for each country is shown in Figure 6.

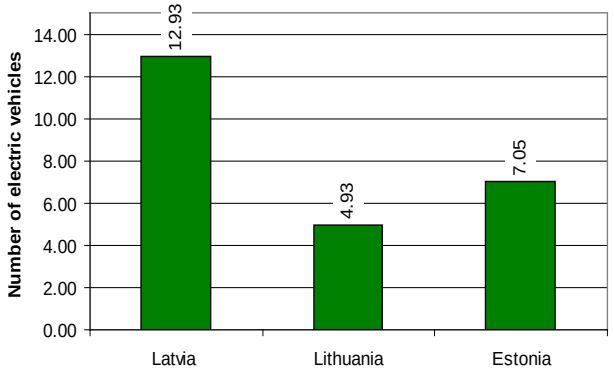

Fig. 6. *Number of electric vehicles per charging station*

In Latvia, the number of electric automobiles is relatively large (194), while the number of charging stations is small. For this reason, the number of electric automobiles per charging station is large – almost 13 electric automobiles. There is only one fast-charging station in Latvia that can serve more than 20 electric automobiles a day. Although the number of charging stations in Estonia is large, the number of electric automobiles serviced a day considerably exceeds the demand in this country, as fast-charging stations are used that can service 6600 automobiles a day.

Conclusions

1. Under various government support schemes, 18 electric automobiles of various models were purchased in Latvia and Estonia. The key factor in the choice of vehicles was the simple way of purchasing the particular model and its popularity, as well as its price.

2. In Latvia, Volkswagen e-Up (135 EV) was the most popular model purchased under the government support scheme, while in Estonia it was Nissan Leaf (266 EV).

3. A classification of energy replenishment stations for electric vehicles and a scheme for their exploitation, depending on the location of a station, were developed.

4. In Estonia, one charging station is available per territory of 274.1 km^2, which ensures a full coverage of charging stations. In Latvia and Lithuania, these indicators are, on average, 17 times lower.

5. Any analysis of charging stations in relation to the total length of main motor roads is not very objective, as the charging stations are mostly concentrated in the largest cities, and the total lengths of main motor roads in the analysed countries significantly differ and do not correlate with the area of the country.

6. The introduction rate of charging stations in Estonia is 82 units per year, whereas in Latvia and Lithuania this indicator is only 4.7 per year.

7. Among the Baltic States, the greatest number of electric automobiles per charging station is reported in Latvia, and the charging stations are not able to service all electric automobiles, as they use slow-charging technology (6-8 h). There is only one fast-charging station in Latvia, which is located by the Road Traffic Safety Directorate building.

8. In Estonia, fast-charging stations whose total capacity is 6600 electric automobiles a day are exploited; the stations can service 6 times more electric automobiles than their number in Estonia at present. Among the Baltic States, the highest level of electric mobility is observed in Estonia, with the charging stations covering the entire territory of the country.

References

1. Elektrotransporta tirdzniecība. [online] [25.03.2015.]. Available at: http://www.impresso.lv/public/lat/elektrotransporta_tirdznieciba/ (In Latvian)

2. 'Latvenergo' autoparku papildina elektromobiļi. [online] [25.03.2015.]. Available at: http://www.delfi.lv/auto/zinas/latvenergo-autoparku-papildina-elektromobili.d?id=39104937 (In Latvian)

3. Elektriautode toetuse statistika seisuga. [online] [31.01.2015]. Available at:http://elmo.ee/11186/ (In Estonian).

4. Elmo – Estonian electromobility programme [online] [31.01.2015]. Available at: http://elmo.ee/elmo/.

5. Reģistrēto transportlīdzekļu sadalījums pēc degvielas veida. [online] [10.02.2015.]. Available at: http://www.csdd.lv/lat/noderiga_informacija/statistika/transportlidzekli/?doc=528 (In Latvian)

6. Berjoza D. Jurgena I., Analysis of the distribution of electric charging station in the Baltic. In: Proceedings of International Scientific Conference „Engineering for Rural Development", May 20 – 22, 2015. Jelgava: LUA.

7. Berjoza D. Jurgena I., Vartukapteinis K. Research in electro and internal combustion engine motor vehicle energy costs. In: Proceedings of International Scientific Conference „Engineering for Rural Development", May 24 – 25, 2012. Jelgava: LUA, pp. 331 – 337.